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A. Vacuum Tubes* (Background)

1. Foreign Influences on Vacuum Tube Technology.

- a. "In the immediate post-World War II period Soviet activities in vacuum tube technology were influenced very strongly by the German developments, methods, techniques and personnel. [redacted] the original Soviet idea might have been to pattern their vacuum tube build-up in accord with the German experience and know-how. If such were the case, the idea did not progress very far [redacted]

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[redacted] the USSR was guided in its plans and programs much more strongly by the USA developments than by the German recommendations. They continued to exploit fully the German technological know-how, their shop and production techniques and their testing and production tools. They had the German specialists in the USSR survey and analyze their war-time and post-war research and development, and were willing to adopt those that fitted their plans and requirements. They used Germans to design and build new devices, testing tools and equipment and to establish several well-organized modern vacuum tube institutes and plants. It was, however, the American methodology that the Soviets were impressed by, and tried to master. One of the important continuing jobs that the German specialists were expected to perform for the Soviets was to elucidate the USA vacuum tube technology and its developments. It got to the point that the best way for a German to convince the Soviets of the merits of his proposal was to claim that it was based upon an American development.

* [redacted] Note: The term 'vacuum tubes' is commonly used to include a wide variety of electronic devices, as well as transistors which replace vacuum tubes. 'Electron tubes,' a generic term used in the title of this report, is coming into more widespread use to cover this wide range of circuit components.

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b.

believe that American methods as a whole are better suited to their purposes than the German, and that the American products lend themselves to much easier production processes in the USSR than the German. The second reason is that the American high-frequency technique is greatly superior to the German. Thirdly, American electronics progress in World War II was exceedingly well reviewed, analyzed and described in readily available publications

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2. Vacuum Tube Activities in the USSR.

- a. "All vacuum tube institutes of MCEI (the Ministry of Communications Equipment Industry) are directed by the Second Main-Administration Group (for vacuum tubes), the Chief Engineer of which is /Tnu/ Sorokin.

Each of these institutes is headed by a technical Director, all of whom are very capable administrators and high-quality technical men. Each institute has also a political commissar, who, however, do not interfere in technical matters.

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- b. "In addition to MCEI vacuum tube institutes there are some vacuum tube capabilities in other institutes of MCEI (ie, Radar Institute in Moscow) and in the institutes of other ministries. Of these the best are those of the Soviet Navy, Air Force and MGB.

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- c. "All Soviet institutes are organized to be fully self-sufficient, and in theory at least capable of all activities required to support their operations. All main vacuum tube institutes have their independent research and development facilities, they design and produce their own testing equipment, they have their own workshops, they produce their own raw material and also do their own metallurgical and chemical work as required. Three reasons for this Soviet procedure which is quite foreign to the normal German procedure are: (1) reliance upon a host of suppliers located frequently at great distances from the vacuum tube plants in laboratories, the tremendous distances in the USSR coupled with poor transportation make the flow of material slow and hazardous; (2) the specialized needs of the vacuum tube institutes for relatively small quantities of high quality material not generally produced elsewhere, and (3) the desire of the Soviets to have as many operating units as possible in any eventuality similar to the invasion of the USSR by the Germans in World War II.

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- d. "In order to eliminate unnecessary duplication of effort and to keep each institute informed on the progress and problems of all others biannual meetings are held of representatives of all institutes on specialized problems in their field. [] a good deal of thought and preparatory work is required for such meetings and that they are considered very effective. At these meetings communal problems are discussed and recommendations are made for assignment of problems to one or more qualified organizations. When the project is assigned to one institute, a special committee is selected from members of other institutes to pass on the progress and outcome. At times the same project is given to several institutes and the best solution is accepted for all. [] this method works very satisfactorily in the USSR.

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3. Svetlana Group (Leningrad)

- a. [] Svetlana Institute occupies a position in the USSR in the field of vacuum tubes not unlike that in the USA of MIT in the field of radar, or the Bell Telephone Laboratories in the field of telecommunications.

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- b. "The Svetlana Institute grew out of the old Marconi plant in Svetlana which manufactured transmitter tubes. It is one of the oldest and best electronics groups in the USSR; it is here that some of the best Soviet electronics specialists at present were trained. (Zuzmanovskiy is one of them.) Svetlana men are not only considered good engineers, they are regarded as an outstanding lot of people and are welcomed in any other plant or institute. All new vacuum tube institutes in the USSR have several Svetlana men assigned to them to serve as a core in technical administration and activities. There were four or five Svetlana men in Fryazino, and the same number in Novosibirsk and Tashkent where some Svetlana people were stationed even during the war.

- c. [] Svetlana engineers are not influenced by the Communist Party ideology, are quite independent and yet are left unmolested because of their technical superiority. For example, there was the instance of the former leader of Svetlana being imprisoned for political unreliability in 1947 without any detrimental effect upon Svetlana personnel.

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- d. "There is also another facet of the special position of the Svetlana group: it is a closed fraternity and its influence can be just as strong in support of progress as against it. An interesting case to support this opinion occurred in 1939/40. A Soviet article was published on magnetrons* in which the author, N F Alekseyev, appears to have made the basic discovery of the use of resonant cavities in connection with magnetrons. It is known that this article had some influence on German magnetron developments during 1941/42 [] this influence was not greater because the Germans at that time were primarily interested in tunable magnetrons and missed fully the potentialities of the fixed magnetron technique so well recognized by the British). In the USSR Alekseyev's work was wholly disregarded by the Svetlana people, responsible for this field of activity, because Alekseyev was not one of the Svetlana group and worked with Kapitza in another institute.

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[] Note: This might refer to an article appearing in the Journal of Technical Physics, Vol 10, 1940, pp 1297-1300, by N F Alekseyev and D D Malairov, which was translated and published in March 1944 issue of IRE Proceedings.

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[] Note: The fact that the Soviets ignored this development is one of the most significant factors in the history of Soviet micro-wave tube development. The Soviets missed a major discovery and exploited only one part of magnetron technique--- continuous wave generation.

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4. Institute 160- Fryazino (Moscow)

- a. [redacted] Institute 160 is the biggest and most important general vacuum tube organization in the USSR because of the presence there of the largest group of German specialists. Two-thirds of the German specialists were well-trained in radar and high-frequency work and [redacted]

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[redacted] all were very keenly aware of the importance of measuring and testing techniques and instruments. The Soviets apparently recognized their potential in testing techniques and most of the German specialists there were assigned to this field, not only to meet the needs of the Fryazino Institute but for the general benefit of all vacuum tube institutes. The Institute built practically all its measuring devices and these [redacted], were better than those produced in Germany.

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- b. "Once the Soviets recognized the importance of laboratory equipment, the German engineers received considerable assistance in their work on such equipment. They were in a position to obtain the necessary materials, even those otherwise not obtainable because of scarcity and were encouraged to initiate, through their Soviet superiors, requests for foreign-made equipment of specialized design or performance characteristics. Other Germans and myself in Fryazino asked on many occasions for the purchase abroad of American-made laboratory equipment advertised in USA technical periodicals and got them.

5. Political Ideology and Tube Research.

- a. "No hindering effects were evidenced in the whole field of electronics and in the specialized field of vacuum tubes by the Soviet Communist ideology or the demands for Party line purity. There are many Party members among Soviet vacuum tube specialists. There are many more who are not.

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[redacted]
Among those in responsible positions there are men who not only are not members of the Party, but are quite outspoken in their non-Party views without any apparent penalties.

- b. "Although there are such cases as a past scientific leader of Svetlana who was imprisoned for his political views and [redacted] Katzmann who, as a Jew, was not considered reliable and removed from Moscow to Novosibirsk; however, there are other cases such as that of Maj Cheletnin [redacted] who was caught in an attempt to desert to the West and who was not punished (in the USSR the penalty for his act is death) but, in addition, was placed in charge of sub-miniature tube development and production in Kalinin and was permitted to travel frequently to Leningrad which is in the zone of severe security restrictions, and of [redacted] Zuzmanovskiy who was quite candid in his views of the highest Soviet officials without any detrimental effect upon his professional position.

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- c. "In Institute 160, as in all others, there was a political commissar. He was totally ignorant in technical matters and had nothing to do [redacted] with scientific activities of personnel of the Institute, but handled such matters as procurement of materiel. This [redacted] is indicative of the general situation in the USSR in regard to the vacuum tube and electronics fields. The Soviets are too anxious to use all their capabilities in building up their potential to permit their political views to interfere with this goal, at least at present.

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B. Vacuum Tube Techniques, Production and Materials

1. General Assessment.

a. [] the basic weaknesses in Soviet electronics and, more specifically in vacuum tubes, were recognized by the Soviet leaders towards the end of World War II in that they were pinpointed and analyzed during the immediate post-war period and [] most of these weaknesses were alleviated by 1951/52. By that time the Soviets had built a number of well-operated and effective institutes for the development and production of all modern vacuum tubes; absorbed the war-time and post-war progress of German and American technology; recognized the importance of effective laboratory and production measuring and testing techniques and set up special facilities for developing and producing testing equipment. They fostered a new generation of vacuum tube specialists, theoretically well-trained in Soviet educational institutions and provided plentiful facilities for their practical on-the-job training in electronics and vacuum tube institutes. Therefore, although the Soviets are still behind the USA in the field of vacuum tubes, a firm basis has been established in the USSR for future growth and expansion, and the growing Soviet vacuum tube potential should be watched closely.

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b. "Soviet vacuum tube specialists have been guided to a large extent by American methodology, technology and progress []"

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c. "Although originally the Soviets concentrated on outright copying of American methods and end-products, the period of imitation by the Soviets of American tube technology has passed, and original native developments by the Soviets or basic native redevelopments of foreign ideas should be on the increase. Specific examples of post-war original Soviet efforts are the multi-cavity high-output, high-efficiency magnetron in the 40-150 cm region, the 'Samovar' klystron and the high-quality theoretical work of Zeitlin on space charge in the reflex klystron."

2. Tube Production.

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b. "At Fryazino one department was established in 1948 to design tube machinery and develop methods and means for tube production. (There were 200 to 300 engineers in this department.) []"

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[] At the beginning of the operation of this department the performance and output of this department was poor due to severe lack of specialists, inadequate tools, meager experience in this field and poor coordination with other departments. []

[] good work was done at Fryazino on copying of American machinery. []

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[] in line with the general betterment in all the quality and quantity of Soviet specialists and with the determination of the Soviets to improve their vacuum tube production, the work of this department must

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have improved. [redacted] although the Germans in the USSR were led to believe that Fryazino was to be a center for design and production of tube production equipment, other and perhaps more effective Soviet institutes must be doing the same work [redacted] as the tube production activities in the USSR [redacted] could not have been supported by the end-products of the Fryazino department for design and production of vacuum tube equipment.

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- c. "Although Fryazino was concerned primarily with preproduction of vacuum tubes, in reality it grew into a large tube production plant. [redacted] there were some 20 automatic units organized on the American production line basis, each unit handling on a step-by-step basis all the required operations. Only general type tubes were produced there at the rate of a tube each five to eight seconds. Thus some 10,000 tubes an hour could be produced there, amounting to an effective output of some 5,000 good tubes per hour based upon a 50% rejection rate, which was computed on the basis of the ratio of bad tubes to the total number of tubes produced.

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Note: Some caution should be exercised in the use of German reports on Soviet vacuum tube production and rejection rate of vacuum tubes. Since most Germans were not permitted to visit the Soviet production plants they might be familiar with the quality and quantity of vacuum tubes produced in preproduction runs on the experimental basis. It is, therefore, possible that their figures might not apply to the true large-scale production runs in the Soviet production plants.

d.

[redacted] the Fryazino machines were of the Eisler make, the same type [redacted] which are purchased by American tube concerns. At Fryazino, and elsewhere, there were some German automatic machines (Funken automaten). There were two of these in Novosibirsk. Some 16 such automats were in Berlin at the end of the war. These were removed by the Soviets [redacted] Sealex machines were also available at Fryazino, [redacted]

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3. Vacuum Tube Materials and Techniques.

- a. "Special work on tube cathode production and materials was done at the Moscow cathode plant. The equipment in this plant was German which was removed by the Soviets from the Telefunken #2 plant in East Berlin. This Moscow plant [redacted] was planned to be large enough to supply the whole USSR needs in cathodes.
- b. "Until about 1950 the Soviets were forced to use standard nickel, which was not good quality for cathode processes. The difficulties in obtaining pure cathode nickel were largely administrative. The Ministry of Metallurgy was not interested in adjusting its production processes to provide a small quantity of high quality nickel and ultimately the Ministry of Communications Equipment Industry had to build its own special plant for production of cathode nickel.
- c. "Phosphors were initially imported from Germany, one of the main sources being Dr Kamm who had a factory in Thuringia. [redacted] Later a special [redacted] laboratory was established by the Soviets for production of phosphor. [redacted] the quality of this phosphor is fully comparable with that of German phosphor. Also an experimental phosphor laboratory was established by a German chemist in Fryazino, with good results.

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- d. [] the Soviets have solved fully or satisfactorily the problem of the use of thorium oxide in cathodes.

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[] thorium oxide material was available in Fryazino which was removed by the Soviets from the Heyden Plant in Dresden. When this supply was exhausted work was initiated at Fryazino on developing substitute materials and on the production of thorium oxide. Serious difficulties were encountered, which difficulties [] are generally well known and are presently being worked on []

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[] the only good thorium oxide in the USSR is that supplied by the Heyden Plant; others were not good enough. [] the problem is still unsolved in the USSR.

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[] the quality of thorium oxide is a matter of luck and the success of Heyden is due to such luck and the characteristics of the raw material used.

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- e. "The Soviet mica was of poor quality. This is based upon the fact that it does not last, particularly under conditions of over and under heating. Operating conditions in the USSR are very hard on tubes as line voltage fluctuates widely -25% to +15%. Mica was carefully handled by the Soviets and was graded into three classes: (a) for high-frequency technique; (b) for use in power tubes and (c) for general purpose tubes. The only source of mica in the USSR is in Zhitomir in the Ukraine. [] there are some deposits of mica in Northern Siberia, []

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[] considerable work was done by the Germans on synthetic mica, []

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[] In the summer of 1951 an important request came from MCEI to a German specialist to study the replacement of mica by ceramic products. []

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Note: Analysis of Soviet general purpose tubes by ATIC indicates that the quality of mica used in these tubes is very good and in fact somewhat superior in quality to ours. It is therefore possible that source was not familiar with the mica situation in the USSR or that mica supplied to the development institutes in the USSR was of poorer quality than that available to the production plants. 7

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- f. [] the use by the Soviets of oxygen-free copper. The basic Soviet requirements for copper for tubes (including magnetrons) were (a) suitable electrical characteristics (b) easy machining. The Soviets have had no trouble with copper and they have had enough experience with copper in other industrial uses so that normal quality copper was considered by the Soviets to be good enough for magnetrons.

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Note: []

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[] There have been other indications that Soviets have been keenly aware of characteristics and importance of oxygen-free copper and concerned with the availability of such copper for this use. 7

- g. "In general, the Soviets are quite familiar with all modern problems and progress in vacuum tube techniques and methods and have proven capable of adapting the foreign developments and ideas to their purposes. The Soviets are presently doing very capable research in the vacuum tube field. They are capable of originality although not adverse to borrowing ideas from abroad. Older specialists such as

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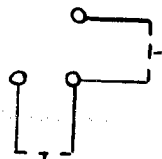
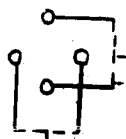
Svetlana engineers are being augmented in this regard by very capable young engineers fully comparable if not better than young German engineers; for example, Zuzmanovskiy and Alekseyev's work on magnetrons, Zeitlin's work on klystrons, Vogelsohn's work on gas tube technique. The Soviets are very imaginative and stubborn people and permit experimental work, at times very costly, on problems which would not be tolerated in Germany or the USA; ie, 'Samovar' which [] would have been abandoned elsewhere, intense work on 10 megawatt and higher magnetrons.

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- h. "The following sketch /Fig 1/ is of the kreuzsonde device [] The device consists of two sets of electrodes at right angles to each other. These were used in the electrolytic trough to obtain two right-angle components of the magnetic field. The device was of considerable laboratory use at Fryazino.

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KREUZSONDE (FIG 1)

4. Research.

- a. "All research in the USSR, including the work on vacuum tubes was centered in and coordinated by the Academy of Sciences in Moscow and by biannual meetings of the research leaders of the important tube institutes /see par 2d above/. Some of the tube research was centered in an institute in Kharkov, presumably for the Ukraine [] that the good work done there was felt in all institutes.

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- b. "Special problems relating to cathode problems were centered in Kiev []

excellent work was supposed to be done there.

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C. General Tubes.

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2. Metal-Ceramic

- a. "The metal-ceramic tubes made at OSW were of the World War II type and construction; ie, LD-9, LD-11 and LD-12. Considerable development work was done on the LD-15 []
- b. "Metal-ceramic tubes were produced at Novosibirsk. The LD-12 grid was in the form of a woven mesh /see Appendix Fig 2a and 2 b/. [] this grid is inferior to the German grid due to wider variations in grid-to-cathode spacing.
- c. "In the summer of 1946 the German group at OSW experimented with a new form of grid to reduce the grid-to-cathode spacing and improve high-frequency cut-off characteristics.

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A glass form was stamped in the form of a cathode and a grid mesh was machine-engraved on it. The grooves of the mesh were filled with carbon and a copper grid was produced by electrolysis. The work was stopped when the Germans were moved to the USSR.

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D. Special Tubes

1. Cathode Ray Tubes

a.

[redacted] conclusion [redacted] the tube might have been used in a special computer then under development, most probably for a ballistic computer, is based on the type of special accuracy requirements supplied to the Cathode Ray Department at Fryazino and on special work on testing devices which the Germans were asked to undertake for the project.

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- b. "Dr Roethe worked on dark trace tubes at OSW. Development work on these tubes was continued in the USSR. In 1950 the work was considered so secret that the Germans were not permitted to work on it.

Note: In line with [redacted] repeated statements that the normal Soviet procedure was to eliminate Germans from the classified projects whenever their development was completed or proceeded to the point that it could be completed by the Soviets, it is possible that [redacted] elimination of the German specialists from further work on dark trace tubes might have meant that the Soviets considered the project sufficiently advanced for production or pre-production engineering.

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- c. "There was a special development in 1946 at OSW on a high-speed writing cathode ray tube. The principle used in these tubes was the same as in the USA and a microscope was used for observing the cathode ray trace.

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At Fryazino a special oscilloscope was built to study the build-up time of magnetrons.

2. Modulator Tubes.

- a. "At first the Soviets tried spark gap modulators for high efficiency jobs but the methods were given up when they later developed high efficiency hydrogen thyratrons and hard tube modulators. Their experience with hydrogen thyratrons was good.

[redacted] Of special interest was the Soviet use of the technique to maintain the hydrogen pressure at constant level by using silver cathode in an iron sponge. This was tried in 1951/52 [redacted]

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[redacted] The Soviet work on iron sponge was very good and the pore-volume was about 50%. The 5 AC-21 tube was an interesting one developed and produced at Fryazino. This is a half-megawatt tube using plate-anode voltage of 35,000 volts. [redacted] no trouble was experienced with this tube.

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TABLE I

MAGNETRONS

Magnetron No 1 /Magnetrons were numbered for ease of discussion during interview 7

the 0.8 cm tube is only in the experimental stage, and possibly in development in Inst 108, Moscow. This is in contrast to information obtained from other German returnees who stated that there was a large production of this tube already in effect.

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Magnetron No 2

This tube is in the planning stage only, and is designed for 1 cm operation (30,000 Mc/S). The proposed construction would follow the wartime Telefunken LMS-14 tube.

Magnetron No 3

This tube is a copy of US 725 magnetron which was designed for the H2X X-band blind bombing radar. This is called "Meddo" by both Germans and Soviets.

Magnetron No 4

This tube, like magnetron No 7, is designed for jamming. It is a CW, mechanically tunable type similar in design to the German LMS-32. A copper tuning ring is mechanically moved toward and away from the cavities.

Magnetron No 5

The tube is a "Rising Sun," fixed tuning, pulse type X-band magnetron. Development is not yet complete /see Appendix, Fig 57.

Magnetron No 6

This is a copy of a Canadian tube of the CV series, S-band.

Magnetron No 7

This tube is CW, mechanically tuned magnetron designed for jamming. /See Appendix, Fig 6.7 An inductive ring is used for tuning in a manner similar to Tube No 4, and German type LMS-32.

Magnetron No 8

This tube is an S-band, pulse-type, fixed-tuning, 2-megawatt peak power such as would be used for early warning. Its efficiency is about 60 - 70%, and frequency stability 1:5,000. The internal structure, coupling device and test equipment were designed by Soviet engineers. The test equipment is reported to have filled a room of about 300 sq ft floor area. The tube development took three years, requiring seven or eight Soviet engineers.

Magnetron No 9

This tube was designed by the Soviets, without German assistance. It was rumored to have 10 MW or larger power output by having the equivalent of a number of two cavity magnetrons in parallel. The tuning was accomplished by wave guide techniques and had a range from 40 to 150 cm. It is probably intended for early warning.

Magnetron No 10

This tube is a copy of the German RM 4032, called the "zero slot" magnetron. It consisted of a cylindrical anode with axially centered wire cathodes. As in the Rice tube, there is a strong axial magnetic field. Two tubes are made--one of a range from 0.8 to 3 cm, another from 3.0 cm to 12 cm. The main use of this tube is experimental.

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TABLE II-MAGNETRONS

Nomenclature	Magnetron No. 1	Magnetron No. 2	Magnetron No. 3	Magnetron No. 4	Magnetron No. 5	Magnetron No. 6	Magnetron No. 7	Magnetron No. 8**	Magnetron No. 9	Magnetron No. 10***
Wavelength, cm	0.8	1.0	3.2	3.0	3.2 - 3.5	9 - 10	9 - 10	10.0	40-150	Two Models 0.8-3 cm 3 cm-12 cm
Fixed or Tunable	Fixed			Tunable	Fixed	Fixed	Tunable	Fixed	Fixed - wave guide techniques	Tunable
Pulse or CW	CW			CW	Pulse	Pulse	CW	Pulse	Pulse	CW
Anode Voltage					20,000		2000-3000v	230,000v	750,000v	4,000 max.
Anode Current					Duty cycle 1-1,000 or 1-2,000		300-400 ma			21 ma
Heater Supply					Thor oxide heater		Directly heated cathode- tungsten	Ba oxide heater		
Output Power					500-600 KW	80-100 KW	600 W (CW)	2 KW Eff. 60-70%	High. Eff. 80%	A few milliwatts
Application			Meddo Radar	Jamming	Radar	Radar	Jamming	Radar, MW		Laboratory Tests
Development Data Start Completion Special remarks	Now in experi- mental stage	Similar to Telefunken LMS-14 only in planning stage	Copy	1949 Intermittent In preprod. stage	1947 Not com- plete	Copy	1946 1948-49	1946 * 1949		
Production Data						Mass pro- duced in 1948	In 1949 several hundred per month			100
Where Developed	Moscow 108?			Fryasino			Fryasino		Fryasino	Regulator equipment developed in Fryasino
Where Produced			Saratov				Fryasino Special unit	In pro- duction		

* Comparable development during the war by the Germans took about one-half the time.

** Inside of magnetron was developed by Soviets coupling and external "plumbing" by Germans.

*** Equals German RM-4032

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F. Klystrons

1. "Soviet klystron work was influenced by both German and US designs /see Table III, page 18. [redacted]

- a. "Klystron #1 - the tube is a copy of a General Electric .42 cm tube, scaled up. The Germans in Fryazino were asked to produce such a klystron for use in testing gear for 8 mm crystal detectors, but found it a hard job. In order to speed their work, the Soviets supplied Fryazino with this klystron, and some additional testing gear, which was produced elsewhere. 50X1-HUM
- b. "Klystron #2 is a copy from a US prototype as copied by the Soviets from a 1949 or 1950 IRE publication. The tuning range was claimed to be 2.5 to 12 cm, and the tuning was accomplished by mechanical control of the cavity /See Appendix, Fig #9/.
- c. "Klystron #3 and #4 were copied from the US Western Electric 725 klystron and German LD-20, which was a copy of the same prototype. Klystron #3 was tuned around 3.2 cm and used for 'Meddo' radar; #4 was tunable from 28 - 29 cm and represents a variation of #4.
- d. "Klystron #5 is the same as the British tube, which was copied by the Germans during the war, known as LD-25, or klystron 1 (Siemens-Halske).
- e. "Klystron #6 is a shortened version of #5. Both these tubes have a glass envelope and use an external tuning cavity.

G. Transistors and Crystal Detectors.

1. "The USSR work on crystal detectors was based upon the German developments in OSW. In 1950 a plant was established in Fryazino to manufacture silicon detectors following OSW procedures. Attempts were made in Moscow to manufacture these detectors following the American procedure. Results were rumored not to be very good and best work was done with the German method. The second step was the introduction of germanium detectors. These were first made in Institute 28 in Moscow but with relatively little success and in 1950 Fryazino started to produce germanium detectors in small quantities on experimental basis. Some production was done at Fryazino, primarily for Institute 160's requirements. The main work of production of crystal detectors must have been done elsewhere.
2. "It was only in 1952, [redacted] that basic development and research work was initiated by the Soviets on transistors. The background of knowledge was available to the Soviets in American publications. There was a book by William Shockley which became available in the USSR in January 1952. A special committee was established in MCEI, consisting of the best specialists in the Soviet Union, to work out the fundamentals of transistors. Everyone was very optimistic, though [redacted] the optimism was unfounded. [redacted] 50X1-HUM

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SECRET

Nomenclature	Klystron No 1	Klystron No 2	Klystron No 3 US type No 725	Klystron No 4	Klystron No 5 K 10-1	Klystron No 6 K 10-2
Wavelength, cm	0.8	2.5 - 12	3 cm	2.8 - 2.9	10 cm	
Fixed or Tunable	Fixed	Tunable			Tunable	
Pulse or CW	CW	(see sketch)			CW	
Anode Voltage	2,000					
Anode Current	220 ma					
Heater Supply						
Output Power	5 milliwatt					
Application	Measuring device	Experimental			Same as English and German Prototypes	Same as K 10-1 but modified in shape
Development Data						
Start		1949	1 year	1951		
Completion		1952	At OSW (LD-20)	Variation of 725		
Special remarks			Copy of US type			
Production Data						
Schedule, etc.						
Where Developed	Moscow (Inst 1087)			Fryazino and Svetlana		
Where Produced	Moscow		Svetlana (presently believed to be in production in Saratov)	Svetlana in production		

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-18-

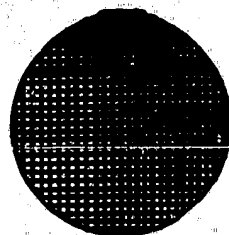
SECRET

TABLE III
KLYSTRONS

Page Denied

APPENDIX

Page 1



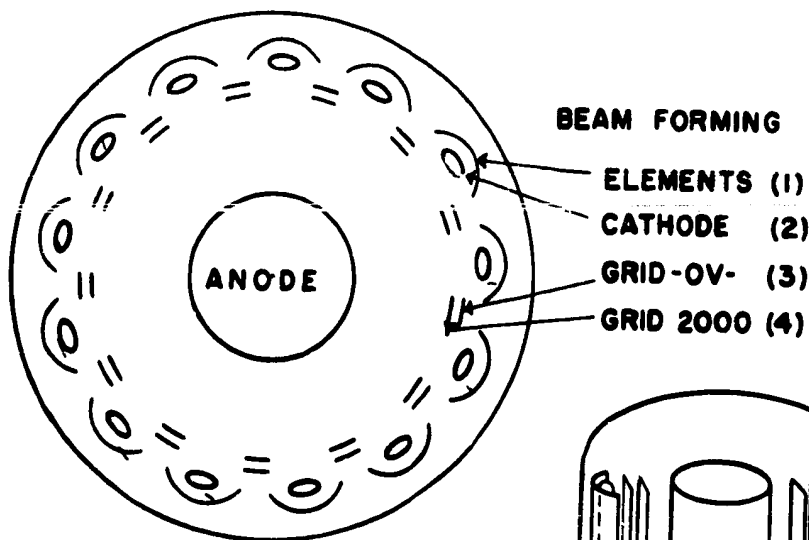
LD 12 GRID



CROSS SECTION

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Fig. 2a and 2b - Details of Metal-Ceramic Tube LD-12



BEAM FORMING

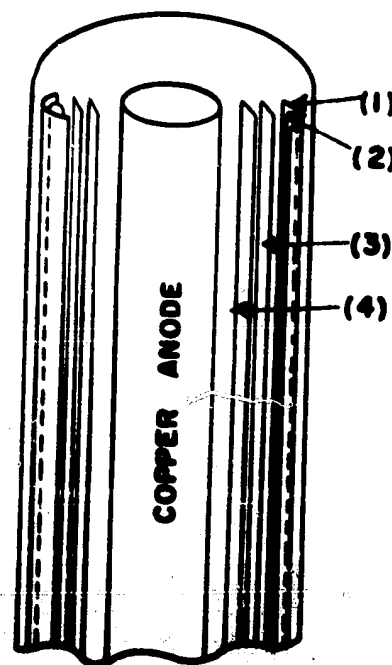
ELEMENTS (1)

CATHODE (2)

GRID-OV- (3)

GRID 2000 (4)

Fig. 3 - Modulator Tube 'Sawover'



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VARIATION OF 5D21

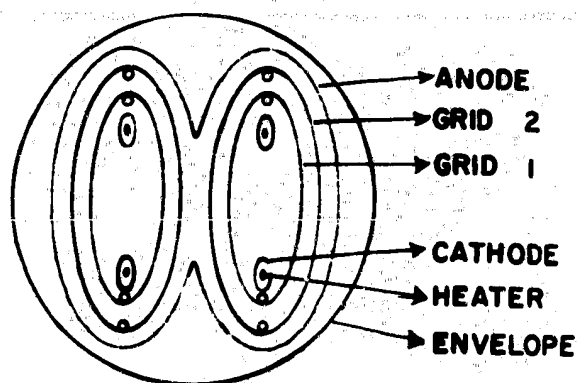


Fig. 4a

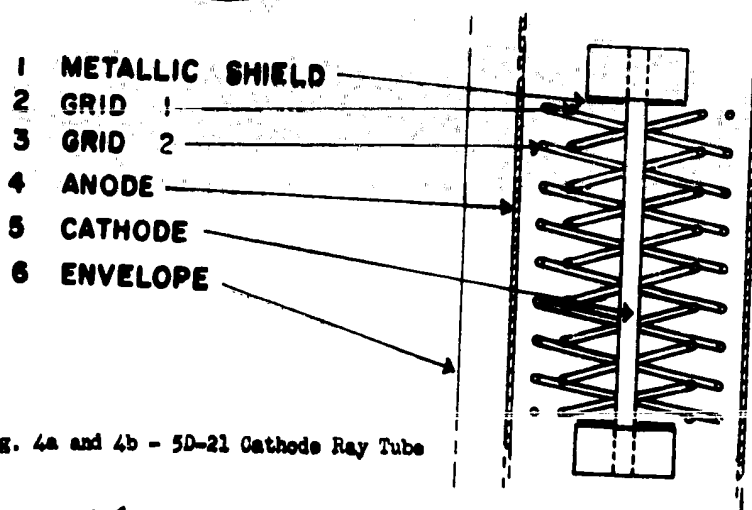


Fig. 4b

Fig. 4a and 4b - 5D-21 Cathode Ray Tube

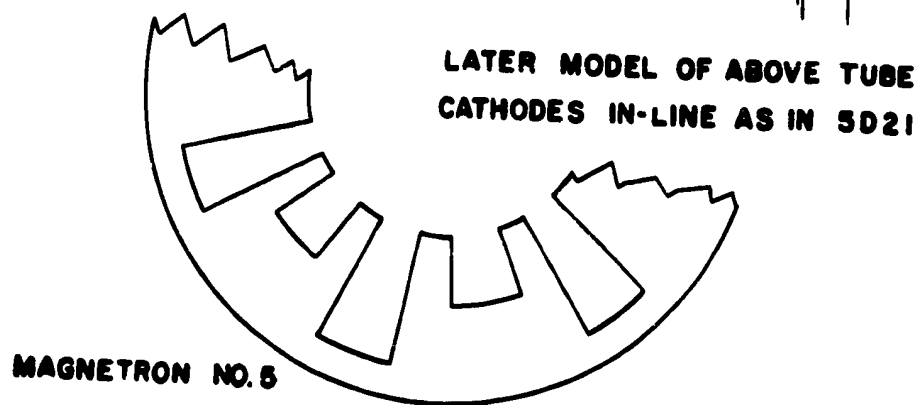


Fig. 5 - 'Rising Sun' Type X-Band Magnetron

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MAGNETRON NO. 7

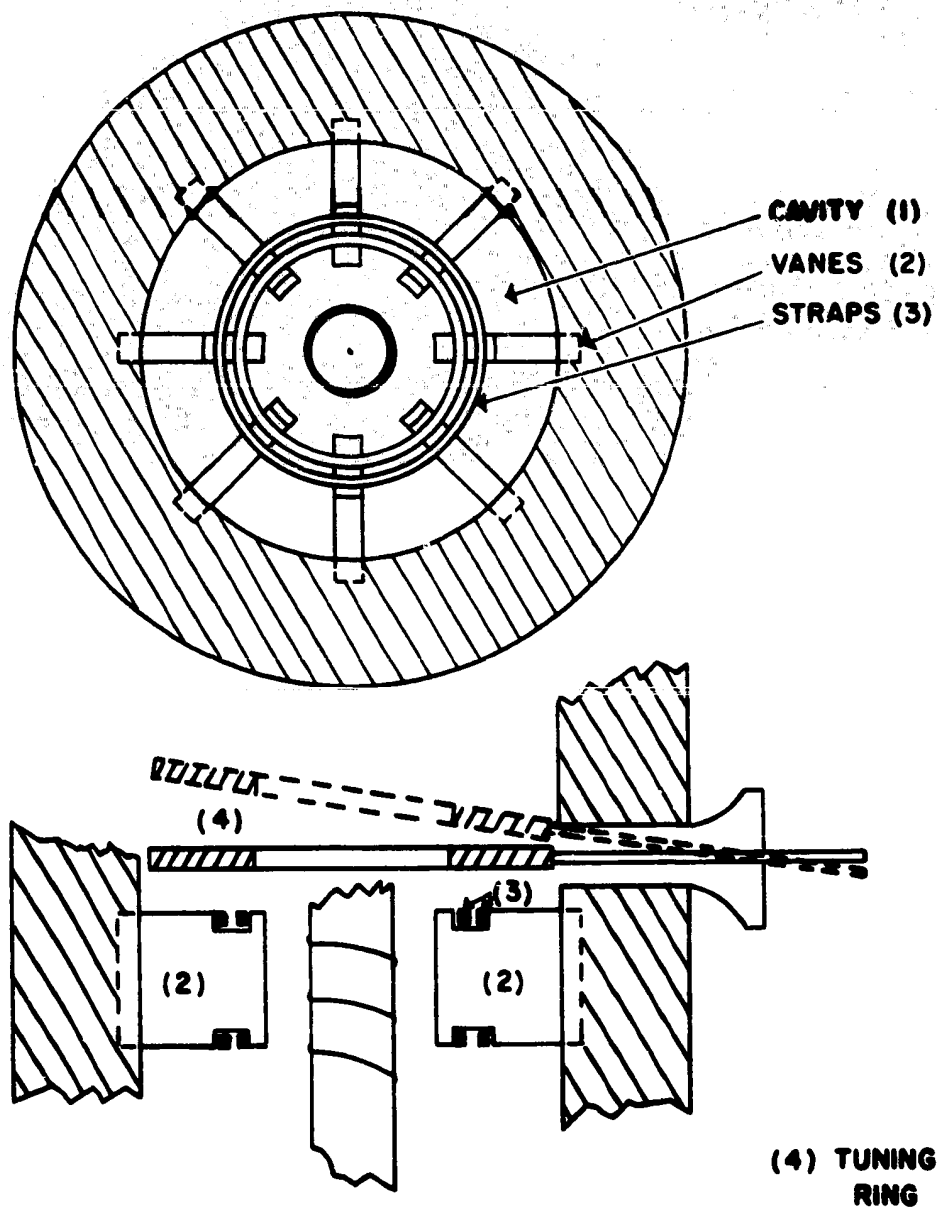


Fig. 6 - Magnetron No. 7 - Jamming

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50X1-HUM

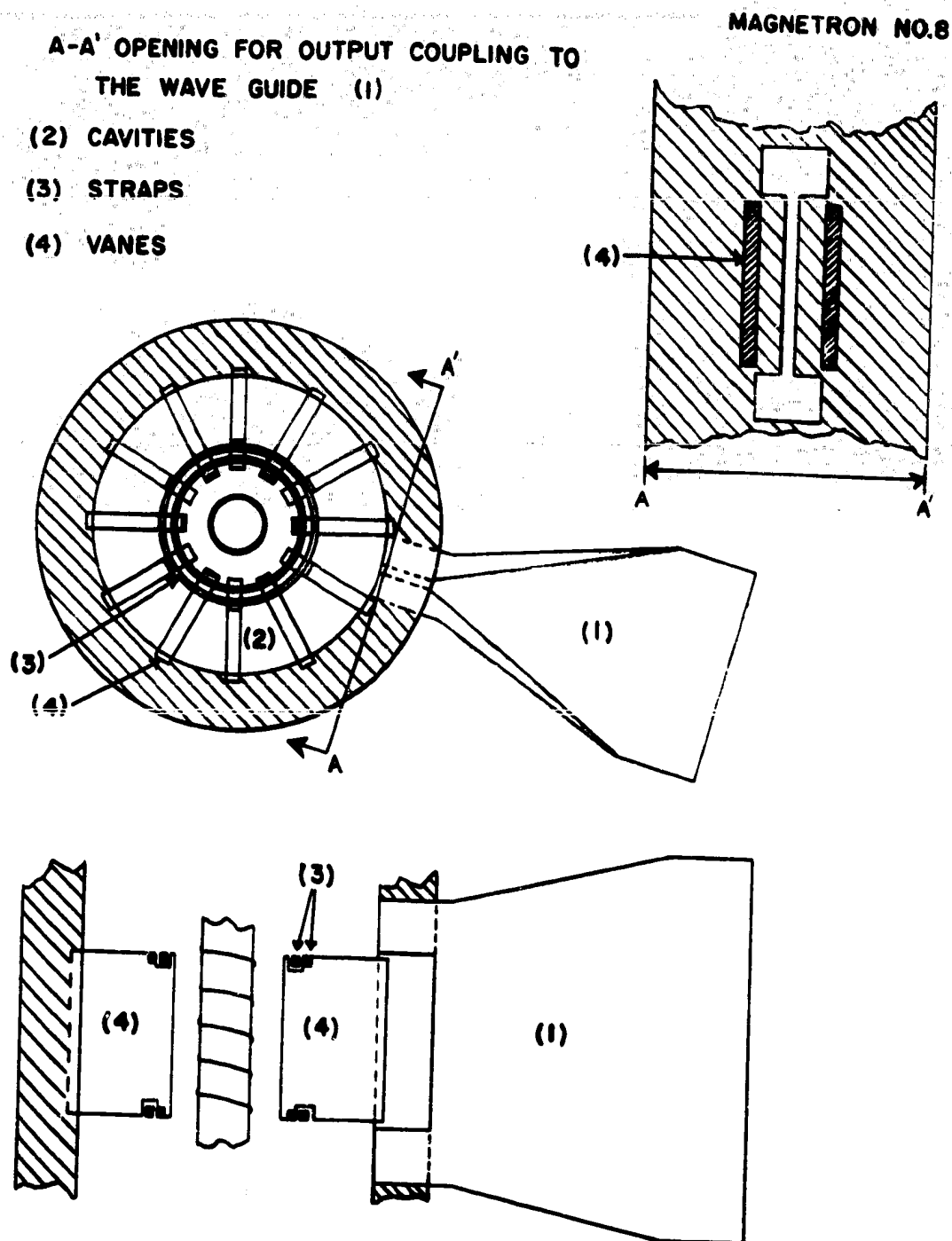


Fig. 7 - Magnetron No. 8 - Radar, Early Warning?

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DIAGRAM APPROX. 10" NO. 9

50X1-HUM

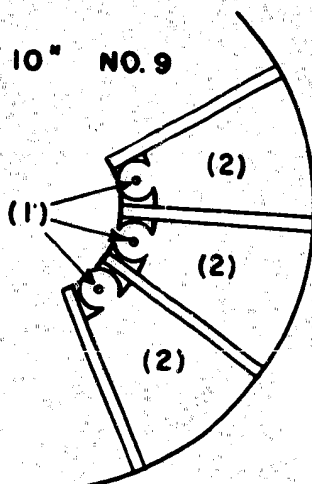
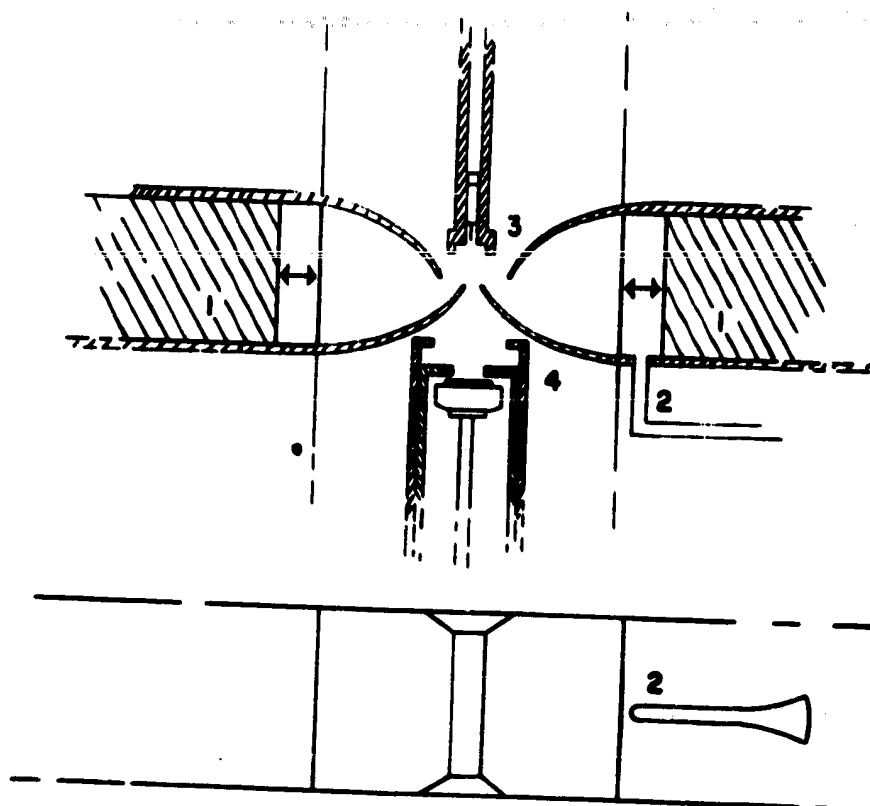
ARRANGEMENT OF CATHODES (1)
IN SEVERAL CAVITIES (2)

Fig. 8 - Magnetron No. 9



- 1 TUNING SLUGS
- 2 OUTPUT COUPLING TO WAVE GUIDE
- 3 REPELLER
- 4 ELECTRON GUN

Fig. 9 - Klystron No. 2 - Tunable